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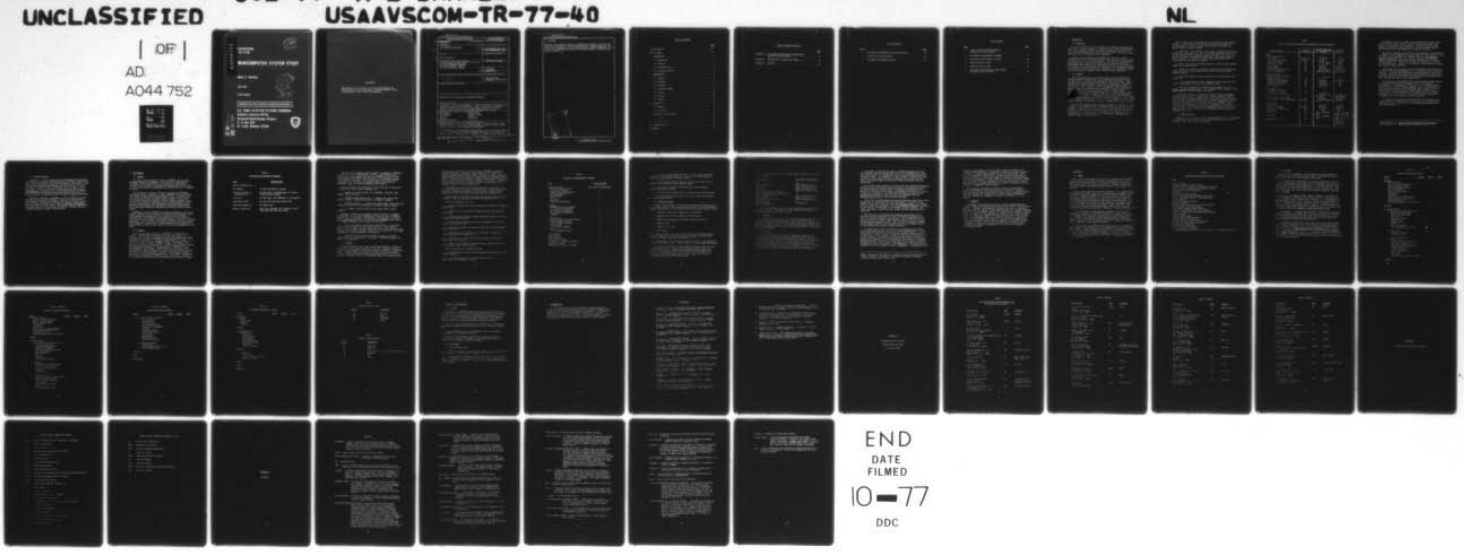

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# MINICOMPUTER SYSTEM STUDY

Mark E. Barkley



July 1977

Final Report



U.S. ARMY AVIATION SYSTEMS COMMAND
Systems Analysis Office
Advanced Methodology Division
P. O. Box 209
St. Louis, Missouri 63166

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| Minicomputer | Compatibility |
| Microcomputer | External Storage |
| Software | Composite |
| Hardware | Large-scale |
| Weighted Evaluation | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Minicomputers were observed in light of United States Army Aviation Systems Command (AVSCOM), Systems Analysis Office (SAO), Scientific and Engineering (S&E) current and forecasted computer requirements.

The SAO computer requirements were isolated based on its present and programmed work load. Commensurate with those computer requirements and the SAO work load, compelling considerations in selecting a minicomputer were amassed and → over

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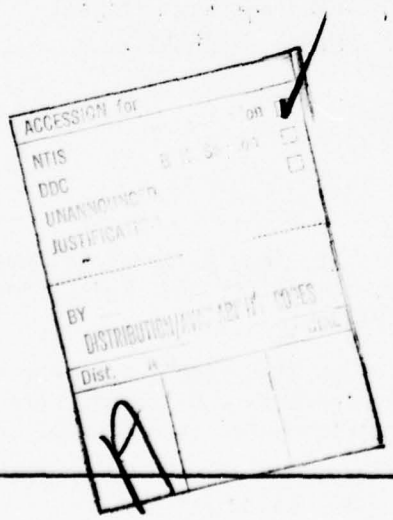
20. ABSTRACT

analyzed. That analysis resulted in criteria and a method for selecting the appropriate minicomputer to provide generalized S&E computer support to the United States Army Aviation Research and Development Command (AVRADCOM), and in particular the AVRADCOM Directorate for Plans and Analysis, Systems and Cost Analysis Division.



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# 1. INTRODUCTION

## 1.1 Background

In the past decade or so, the computer-user community witnessed the emergence of low-cost computers, specifically, the so-called minicomputers. They are the computers within the computer industry which incurred the most significant growth during the cited time period. (Historical sales statistics add some credence to the statement.)

Calendar Year (CY) 1962 can be thought of as the first time of noteworthy publicity for the application of minicomputers to the solution of a special class of real-time problems. That publicity disclosed that minicomputers were being (or could be) used to perform a whole host of specialized tasks (especially in dedicated real-time type applications), for example, to obtain solutions to a certain class of aerospace problems, for recording the results of certain experiments, for controlling certain precision scientific equipment, and as traffic light controllers.

## 1.2 Problem

The United States (U.S.) Army Troop Support and Aviation Materiel Readiness Command (TSARCOM) has two IBM System 360-65 computers which are dedicated to scientific and engineering (S&E) applications. These computers represent the hardware for the U.S. Army Materiel Development and Readiness Command (DARCOM) Midwest Regional S&E Computer Center, located in St. Louis, Missouri. Being the DARCOM Midwest Regional S&E Computer Center, it has many retail customers. Among them are the U.S. Army Armament Research and Development Command (ARRCOM), Rodman Laboratory, and U.S. Army Management Engineering Training Agency (AMETA), Rock Island, Illinois; U.S. Army Air Mobility Research and Development Laboratory, Ft. Eustis, Virginia; Materiel Testing Directorate, Aberdeen Proving Ground, Maryland; U.S. Army Bell Plant Activity, Ft. Worth, Texas; TSARCOM Product/Project Managers (PMs), St. Louis, Missouri; and U.S. Army Aviation Research and Development Command (AVRADCOM), St. Louis, Missouri.

Note that the retail customer concept for computer resources suggests a sharing of the computer (as well as computer time) on the part of these customers. Additionally, it suggests that S&E computer users purchase a block of computer time from TSARCOM. As a matter of fact, this is how the concept was implemented and is maintained. The amount a retail customer pays for computer resources is principally contingent upon the amount of computer time he (she) uses.

When a computer user determines that he (she) really needs computer support, he (she) should first evaluate the available alternatives. The following is a partial listing of the questions that should be answered before he (she) proceeds:

a. What level of S&E computer support does my organization require? (Things to be considered are: Who is to prepare, operate, and maintain the S&E computer system, computer programs, and data files? What size computer is needed to satisfy my organization's S&E computer requirements? When will my organization receive the appropriate output--turnaround time with respect to needs?)

b. What is the most cost-effective means of providing S&E computer support to my organization?

c. How do the regular and nonregular duty hours of my organization differ from those of the organization(s) which are to provide S&E computer support?

d. Which S&E computer software packages will my organization have access to?

e. Is my organization's present computer hardware compatible with that of S&E computer retailers on my candidate list?

f. Does my organization's present computer hardware allow for growth and upward compatibility? (Are my organization's computer support needs expected to remain virtually constant?)

In view of the above and because of austere funding, the Systems Analysis Office (SAO), U.S. Army Aviation Systems Command (AVSCOM), initiated the Minicomputer System Study. The purpose was to determine the projected minicomputer/microcomputer hardware and software requirements for the Directorate for Plans and Analysis, AVRADCOM, develop a procedure for selecting a minicomputer/microcomputer system which satisfies these requirements, and derive an estimate of the benefits that could accrue from procuring and implementing the appropriate minicomputer/microcomputer system within the Directorate for Plans and Analysis, AVRADCOM.

## 1.3 Characteristics

Table 1 shows a range of the typical characteristics of a minicomputer/microcomputer from a minimal through a fairly sophisticated piece of hardware. (Note these before proceeding.)

TABLE 1

TYPICAL MINICOMPUTER/MICROCOMPUTER CHARACTERISTICS AND FEATURES

| CHARACTERISTICS | FEATURES AVAILABLE | | |
|---|---|---|---|
| | MINIMUM | AVERAGE | MAXIMUM |
| MEMORY | | | |
| Word Length (Bits) | 8 | 8 or 16 | 32 |
| Size (Words) | 1,024 to 4K | 4K to 32K | 4K to 256K |
| Increment Size (Words) | 1,024 | 4,096 | 8,192 |
| Cycle Rate (KHz) | 125 | 571 to 1,000 | 2,000 |
| (Cycle Time, μSec) | 8 | 1 to 1.75 | 0.5 |
| Parity Check | No | Optional | Standard |
| Memory Protect | No | Optional | Standard |
| Direct Addressing (Words) | 256 | 256 to 4,096 | All of Core |
| Indirect Addressing | No | Single/Multilevel | Multilevel |
| CENTRAL PROCESSOR | | | |
| General-Purpose Registers | 1 | 1, 2, 3, or 4 | 12 |
| Index Registers | 0 | 1 | 15 |
| Hardware Multiply/Divide | No | Optional | Standard |
| Immediate Instructions | No | Half yes | Yes |
| Double-Word Instruct | No | Mostly yes | Yes |
| Byte Processing | No | Half yes | Yes |
| INPUT/OUTPUT (I/O) | | | |
| Programmed I/O Channel | 1 | 1 | 1 |
| I/O Word Size (Bits) | 8 | 8 or 16 | 32 |
| Priority Interrupt Lines | 1 | 1 Standard to 64 Optional | 2 Standard to 256 Optional |
| Direct Memory Access (DMA) | No | Optional | Optional |
| I/O Maximum Transfer Rate (DMA) | 125,000 | 400,000 to 600,000 | 1,000,000 |
| OTHER FEATURES | | | |
| Realtime Clock | No | Optional | Standard |
| Power Fail/Restart | Optional | Optional | Standard |
| Largest Disk (Megabits) | No | 2.1 to 9 | 183.6 |
| Assembler | Yes | Yes | Yes |
| Interpreter | No | Basic, FORTRAN, PLM | Basic, FORTRAN, ALGOL, APL, PLM |
| Compiler | No | Basic, FORTRAN, PLM | Basic, FORTRAN, ALGOL, APL, PLM |
| Operating System | No | No | Real-Time, Background, Foreground |

Minicomputers typically possess fast processing (core cycle times and peripheral transfer) rates, relatively short word lengths, and adaptable input/output (I/O) structures. The price of one of these appears to be based on such attributes as the word length, scope of the instruction set, and adaptability of the I/O structure.

The central processor units (CPUs) of minicomputers or microcomputers are generally single-address binary processor units with negative numbers expressed as two's complements. However, there are distinguishing characteristics among them. The principal ones are the following: number of accumulators provided; instruction decoding; and interrupt handling capability. Typical CPUs possess an instruction set from 60 to 100 instructions. However, it is possible to find CPUs which possess more than 200 instruction sets.

At one time, the principal role of a minicomputer or microcomputer was that of performing management control, data acquisition, and display functions. They were then dedicated to performing the following kinds of tasks: monitoring and controlling specified processes; monitoring specified processes and displaying prescribed output; data acquisition; data reduction and analysis; and communication.

To distinguish a minicomputer from a microcomputer, Barden[1] offered the following statement (the statement below is a paraphrase): A minicomputer is an inexpensive (costing up to a few thousand dollars) physically small, general-purpose computer, while a microcomputer is a minicomputer possessing a microprocessor chip or chips as its CPU. Observe that, from the previous statement, one could not obtain a crystal clear distinction between a minicomputer and a microcomputer. Not enough facts were offered, to have done so would have been an horrendous task, and certainly not worth the effort.

In view of the discussion presented above, any rationale offered in the future for a minicomputer will also apply to a microcomputer. (Appendix A shows a select list of minicomputers/microcomputers and their manufacturers.)

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[1]William Barden, Jr., How to Buy Minicomputers and Microcomputers (Indianapolis, IN: Howard W. Sams and Company, 1977), P. 11.

## 1.4 Literature Search

References 1, 7, and 12 disclose that minicomputers/microcomputers are available in numerous configurations and are highly suited for two basic kinds of processing, batch and time-sharing. Additionally, they show that minicomputers/microcomputers are being used to aid in the performance of many (as well as different kinds of) tasks, with few exceptions. Several of these applications were cited above, under Characteristics. Needless to say, a given manufacturer's literature (Reference 16) makes assertions about how useful and versatile its product would be in enhancing solutions to specific user type problems.

References 2 through 6, 8 through 11, and 13 through 15 disclose that when a potential user commences a search for a minicomputer/microcomputer, he (she) should identify his (her) particular requirements and then concentrate on obtaining the computer configuration which best meets his (her) needs. Additionally, special consideration should be given to on-line storage, peripherals, software, monitors, language processors, editors, and operations.

## 2. REQUIREMENTS

### 2.1 General

The scope of this study was limited to AVRADCOM's S&E and data management computer requirements. This action was taken because of the thrust of the potential work load (research and development oriented) and since many of the operations research and cost analysis projects can be properly accomplished only through the use of a computer as a tool.

The following is a partial listing of the kinds of programmed assignments which are required to support AVRADCOM functional offices and resident DARCOM Project/Product Managers (PMs): system/end-item life cycle cost modeling, system/end-item survivability and vulnerability modeling, support computer graphics--network, schedule and risk analysis modeling, organization force structure modeling, routine cost and system analyses, and implementation and maintenance of the Modernized Army Research and Development Information System (MARDIS) and of the Second Generation Comprehensive Helicopter Analysis System (SGHAS).

AVRADCOM and resident DARCOM PM personnel programmed to use the S&E computer system consist principally of scientists and engineers (specifically operations research analysts, various kinds of engineers, mathematicians, and mathematical-statisticians), but also others who are not necessarily trained or experienced computer scientists or computer programmers. These personnel are expected to develop their own applications software or exercise applications software which are designed for them by others to satisfy their specific S&E and data management requirements.

### 2.2 Hardware

One of the principal concerns of AVRADCOM is to accomplish its mission. To efficiently and effectively attain this goal, it is mandatory that the proper resources (personnel and hardware) be readily available and accessible to AVRADCOM for employment at all times. The resource of interest here is computer hardware (a CPU, main memory--core, solid state electronic or bubble storage, input/output (I/O) devices, and external storage devices), in particular, a general purpose minicomputer/microcomputer for direct support of AVRADCOM's S&E and data management requirements. AVRADCOM offices, particularly the Directorate for Plans and Analysis, Systems and Cost Analysis Division, need access to computer hardware which has the capability to support their S&E and data management requirements. This computer hardware may be internal or external to AVRADCOM's on-site facilities. (See Table 2 for a possible configuration of minicomputer/microcomputer hardware.)

TABLE 2

MINICOMPUTER/MICROCOMPUTER HARDWARE

| ITEM | SPECIFICATION |
|---|---|
| Central Processor Unit | |
| Main Memory | At least 32K bytes of storage |
| Floppy Disk Drive, or Diskette Drive | At least dual, with 250K bytes of storage/ floppy disk or diskette |
| Disk Drive | At least dual, with 10M bytes of storage/disk |
| High Speed Printer | At least 350 lines per minute (LPM) |
| Punch Card Reader, or | 80 column card |
| Magnetic Tape Drive | Dual, with standard 7 or 9 channels, 800 or 1600 bytes per inch (BPI) tapes |

Consider the case where computer hardware is external to AVRADCOM's on-site facilities. AVRADCOM would then be a user, as previously discussed, and consequently serviced by a computer retailer or wholesaler through batch, remote job entry (RJE), or time sharing option (TSO) terminal processing. (This assumes that the computer retailer or wholesaler will possess the computer hardware that satisfies AVRADCOM's total S&E and data management requirements.)

Reasonable sources for obtaining a listing (and even a comparative listing) of available computer hardware are:

a. Manufacturers (IBM, UNIVAC, DEC, BURROUGHS, Interdata, Data General, PRIME, HP, etc.)

b. DATAPRO Research Corporation -- a company that, among other things, compiles a comparative analysis of computer hardware.

c. Auerbach Services -- a company that, among other things, provides information on particular manufacturers and their computer hardware.

d. U.S. General Services Administration (GSA) Federal Supply Schedule.

Similarly, consider the case where computer hardware is internal to AVRADCOM. In this case, AVRADCOM has to acquire a set of computer hardware which is supposedly cost-effective and satisfies as a minimum the quick-response portion of its S&E and data management requirements. This computer hardware should possess the following:

a. A CPU, main memory, input/output (I/O) devices -- card reader and high-speed printer, and mass storage devices -- direct access storage devices (DASDs), magnetic/paper tape drives, etc. which are only large enough to satisfy the user's total (or as a minimum his (her) quick-response) S&E and data management requirements.

b. Compatibility with existing computer hardware, and permits upward compatibility and growth. (This case is assumed throughout the remainder of the paper.)

2.3 Software

Computer software in this paper includes the following: operating system (executive, supervisor/command, I/O logic, language processors--assembler, cross-assembler, high level language compilers or interpreters (COBOL, FORTRAN, PASCAL, PLM, BASIC, APL, etc.), emulating packages, editors, support, and applications packages (See Table 3 for a minimum software requirements list.) A significant number of the minicomputer/

microcomputer manufacturers, software houses (INFORMATICS, DATAPRO Research Corporation, Management Science America, Inc. (MSA), etc.), original equipment manufacturers (OEMs), and service bureaus produce and market adequate computer software to support most user computer hardware systems. Consult the International Computer Program (ICP) Directory and other software directories for more information on software. (See the Glossary for a definition of peculiar terms.) An additional source of computer software is other computer users.

It behooves every potential software purchaser or user to be careful when he (she) takes inventory and evaluates his (her) organization's particular software requirements or seeks external software support. Otherwise, he (she) may not get what was originally bargained for.

Observe Table 3, two items of primary importance will be discussed in detail. They are operating system (OS) and system utilities.

First, the components of an OS:

a. Intertask communication permits one task or program to communicate with another.

b. Shared files permit several programs to access the same data concurrently.

c. Shared programs increase computer system efficiency and decrease the amount of memory required.

d. Multiprogramming permits more than one program to run on the computer system at one time.

e. Multitasking permits more than one task to run on the computer system at one time.

f. Batch gives a user the facility to run work in background. It is a noninteractive mode of operation.

g. Core dump gives a user the facility to obtain a snap shot of memory when a failure occurs.

h. Power failure/recovery routines protect a computer from losing its data when a power failure occurs.

Last, the components of system utilities:

a. A conversational editor permits the user to enter data programs into the computer.

b. A command language is the medium through which the user communicates with the computer system.

TABLE 3

MINICOMPUTER/MICROCOMPUTER SOFTWARE

| ITEM | SPECIFICATIONS |
|---|---|
| Operating System | Operational; maintainable |
| Intertask Communication | " |
| Shared Files Support | " |
| Shared Programs (Reentrant) | " |
| Multiprogramming | " |
| Multitasking | " |
| Batch | " |
| Core Dump | " |
| Power Failure/Recovery | " |
| Language | |
| FORTRAN Compiler/Interpreter | " |
| PL/I Compiler/Interpreter | " |
| APL Compiler/Interpreter | " |
| BASIC Compiler/Interpreter | " |
| Assembler | " |
| System Utility | |
| Conversational Editor/Text Editor | " |
| System Command Language | " |
| Stored Command Functions | " |
| Task Builder | " |
| File Transfer Programs | " |
| Sorts | " |
| On-line Debugging Tools | " |
| File Handling | " |
| Communication | " |
| Device Support | " |
| Statistical Package | " |
| Mathematical Programming Package | " |
| Emulation Package | " |
| Input/Output Logic or Circuitry | " |

c. A set of stored command functions is a facility which permits the user to store command functions. This facility saves times and simplifies operations which may occur later.

d. A task builder produces tasks for later use so that a task or program can be exercised on the computer system.

e. File transfer programs facilitate data transfer between different peripheral devices.

f. A SORT routine arranges data in accordance with prescribed keys.

g. On-line debugging tools permit the user to debug (her) programs in a conversational mode.

## 2.4 External Storage

External storage media in this paper is considered to mean principally mass storage, that is, direct access, magnetic tape or card, paper/mylar tape, and paper card. It may take any one of the following specific forms:

a. DAS (drum, rigid disk, floppy disk, or diskette).

b. Magnetic tape (various diameter and track sizes).

c. Magnetic cassette tape (cartridge; standard and micro).

d. Magnetic card.

e. Paper or mylar tape.

f. Paper card.

Hill offers a useful discussion on DAS; Hogg offers additional useful remarks on DAS, particularly floppy disks; and Boyle discusses some details of magnetic tape cassette storage.[3, 10, 11]

The advantages of external (mass) storage are ease of record handling, efficiency of repeated use, accuracy, and high volume storage performance.

Of the principal external storage media previously cited, one order of popularity is disk, floppy disk or diskette, magnetic tape, drum, magnetic cassette tape, punched paper card, and punched paper/mylar tape. This is partially due to the following attributes which each possess to some extent: speed, ease of data recovery, volatility, transportability, reliability, and economy.

The storage capability of the storage media listed below is estimated to be as shown:

| Storage Medium | Estimated Storage Capacity |
|---|---|
| Drum | Open |
| Rigid or hard disk | About 10M bytes and up |
| Floppy disk | About 250K bytes and up |
| Diskette | About 100K bytes and up |
| Magnetic tape (9 channel, 2400 feet, 1600 BPI, block size 20, 80 characters/record) | About 30.72M bytes and up |
| Magnetic cassette tape | About 125K bytes and up |
| Magnetic card | About 5K bytes and up |
| Punch paper or mylar tape (150 feet roll) | About 100K bytes and up |
| Punch paper card | 80 characters |
| Magnetic stripe card | |

Data may be recorded on each of these storage media under or without format control. In general, one may record more information on a medium when he (she) uses format control.

## 2.5 Sources

Minicomputers/microcomputers can be acquired through many sources; among them are computer manufacturers, OEMs, and service bureaus. As previously mentioned, the GSA Federal Supply Schedule of computer hardware may be used as a source. Additionally, most computer manufacturers furnish assistance and information on the state-of-the-art and upcoming hardware and software.

## 2.6 Analysis

Today's minicomputer/microcomputer hardware is reported to be state-of-the-art. Accordingly, almost any manufacturer can offer a potential purchaser or user a configuration of computer hardware that is reliable and which satisfies his (her) particular needs. (Minicomputer/microcomputer users who presented papers at the American Institute of Industrial Engineers (AIIE) Seminar entitled "Minicomputers: The Application Explosion," conducted by the AIIE, Chicago, Illinois, April 27-29, 1977, gave some credence to the previous statements.)

For example, during the AIIE Seminar, Armstrong offered the following statement, "Because minicomputers grew up in a different world, they tend to be reliable to a degree those of us with large machine experience find unbelievable. The complexity of their systems is increasing, bringing with it some software reliability problems, but overall, you can expect a mean time between failures which large system owners can only dream about."[1]

One can infer from historical statistics that minicomputer/microcomputer CPUs are significantly more reliable than their large-scale big brothers. At the AIIE Seminar mentioned above, minicomputer/microcomputer users generally cited fewer than 24 hours of minicomputer downtime over a period of one year of operation. Minicomputer/microcomputer hardware system problems were reported to exist, but they were attendant with the mechanical moving parts of the peripheral equipment.

The price of a minicomputer/microcomputer hardware system from a given manufacturer is competitive with that from another. The price of the system, in addition to what was cited under Characteristics, is contingent upon the particular requirement of the minicomputer/microcomputer purchaser or user and the configuration of the hardware actually procured. New "chip" technology is permitting even further and more significant price reductions.

Note that select minicomputer/microcomputer manufacturers offer CPUs which may be linked with a variety of peripheral equipment, even those from different computer manufacturers. This capability should be one of the areas of primary concern when purchasing or seeking to use a minicomputer/microcomputer system. That is, such attributes as compatibility, upward compatibility and growth need to be an integral part of any minicomputer/microcomputer systems evaluation.

As noted earlier, select software for a minicomputer/microcomputer system can be obtained from most of the computer manufacturers. It can also be obtained from OEMs, service bureaus, software houses, and user organizations. However, there are inherent problems associated with some of these sources. For example, the OEMs, service bureaus and software houses may be dependants of the user organization because of the client-seller communications problem and bankruptcy--some of these institutions are underfinanced. (Check these institutions as you would any other for reputability, financial capability, and competence.) (Note that financial incapability does not necessarily imply incompetence.) Communications and

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[1]Jack C. Armstrong, "Minicomputer as Extension of Central Data Processing" (paper furnished to the American Institute of Industrial Engineers, Chicago, Illinois, April 27-29, 1977).

bankruptcy are purported to be the primary problems associated with software misunderstandings. Accordingly, a user would do well to ensure that there is a mutual understanding of the contract problems (particularly the detailed scope of work), and that the institution which is awarded a contract is financially capable of completing and maintaining the software it develops. On the other hand, if the applications software are not procured, the user organization is required to commit a significant share of its personnel resources to the task of developing and maintaining it, frequently a costly endeavor.

The DAS devices and media are superior external storage methods. (See the literature on each type relative to its merits.) However, if time and space are not of the essence, other external storage devices and media may satisfy your organization's external storage requirements. (Consider the bulk and frequency of the need of the data, etc. to be stored.)

## 2.7 Benefits

Procurement and implementation of an in-house minicomputer/microcomputer system within the user organization could result in the following benefits: improved responsiveness, increased user control, increased management control, absence of telecommunications costs, reduced overhead costs for use of a computer system -- no requirement to maintain a computer system which overfills the organization's needs, placing computing power where it is most used, reduced filing and storage costs, a more portable and reliable computer system, less space for placement of the computer system, reduced movement on the part of analysts and programmers, and increased efficiency from the computer hardware and personnel resources perspective. Observe, the previous statement was not meant to be an exhaustive delineation of the benefits of an in-house minicomputer/microcomputer system.

## 3. EVALUATION

### 3.1 General

When a potential purchaser or user of a minicomputer/microcomputer system becomes serious about the selection and acquisition of a minicomputer/microcomputer system, he (she) should develop and establish a formal study plan. That study plan should as a minimum include the following: problem definition and data collection, data analysis, and decision.

During problem definition and data collection, it is imperative that the potential purchaser or user of a minicomputer/microcomputer system delineate all potential problem and application areas in which it may be useful. (Refer to Exhibit 1 for a list of possible minicomputer/microcomputer application areas.) Additionally, he (she) should list such items as current and projected work load, the backgrounds of the current and potential purchaser or user employees, the suspense dates of the work load, file storage requirements, growth potential, manual and automated processes, existing computer system availability and capability, security considerations, backup and recovery procedures, etc.

During data analysis, the potential purchaser or user of a minicomputer/microcomputer system should delineate his (her) specific requirements (even if he (she) must obtain help), determine a possible set of vendors (by obtaining information from computer manufacturers, trade journals, and companies such as DATAPRO Research Corporation, Auerbach Services, etc.), and prepare and submit requests for proposals/quotes (RFPs/Qs) to the identified vendors.

During decision, the potential purchaser or user of a minicomputer/microcomputer system needs to follow a preestablished assessment procedure. That assessment procedure should reflect the potential purchaser's or user's previously established statement of the minimum hardware/software requirements, including a scheme for assigning the appropriate relative rating and weight for a given factor. (A proposed assessment procedure follows.)

EXHIBIT 1

MINICOMPUTER/MICROCOMPUTER APPLICATION AREAS

AREA

Process Control
Numerical Control of Machine Tools
Process Control: Security; Environmental Conditions
Direct Control of Machines and Production Lines
Automated Testing and Inspection
Telemetry
Data Acquisition and Logging
Control and Analysis of Laboratory Experiments
Analysis and Interpretation of Medical Tests
Traffic Control
Shipboard Navigation Control
Message Switching
Communications Controllers for Larger Computers
Communications Line Concentrators
Programmable Communications Terminals
Peripheral Controllers for Larger Computers
Control of Multistation Key-to-Tape/Disk Systems
Display Control
Computer-aided Design
Typesetting and Photocomposition
Computer-assisted Instruction
Engineering and Scientific Computations
Time-sharing Computational Services
Business Data Processing
Analog to Digital Conversion
Text: Editing and Processing
Transaction Systems: Point of Sale; Reservations; Attendance Reporting

## 3.2 Procedure

There are three components to the proposed assessment procedure for selecting ans acquiring a computer system: purchaser/user requirements, factor analysis, and performance measurement.

The purchaser/user requirements, as previously mentioned, should be completely delineated to include the minimum constraints for each item placed on the technical requirements list. For example, consider several thresholds for a high-speed printer (HSP): A 132 character print line, 10 characters per inch, interchangeable print belts with 48, 64, or 96 EBCDIC character sets, and at least a 350 LPM for a 96 EBCDIC character set is required.

Exhibit 2 is a suggested factor analysis schedule. The weight and rating assigned to an entry in this schedule could be those which are shown in Tables 4 and 5, respectively. (However, it is recommended that the potential purchaser or user develop his (her) own weight and rating scheme.) Tables such as these should be used for assigning values to each item listed on the factor analysis schedule. A schedule should be prepared for each vendor/producer of a target hardware or software system to include calculating a composite vendor/manufacturer score.

The analysis of a target vendor/contractor, completion of the factor analysis schedule, and a comparison of the factor analysis schedules for the target vendors/contractors constitute the factor analysis. (Statistical theory and techniques may be used to facilitate the comparative analysis among the target vendors/contractors.)

Performance measurement can occur either when a prospective customer has selected and acquired a particular computer system or made contact with a current purchaser or user. In either case, performance measurement can result. A composite performance measurement score for a given vendor/manufacturer may be obtained in the same manner as the composite vendor/manufacturer score. Exhibit 3 is a suggested performance measurement schedule. Again, the weights and ratings from Tables 4 and 5 may be used. (Note that performance measurement assumes that there is experience with the computer system.)

EXHIBIT 2

WEIGHTED EVALUATION SCHEDULE

| FACTOR | WEIGHT | RATING | SCORE |
|---|---|---|---|
| A. HARDWARE | | | |
| 1. COMPANY RELATED | | | |
| Overall EDP/ADP Experience | | | |
| State-of-the-Art Upkeep | | | |
| Overall Management Quality | | | |
| Service Reputation | | | |
| Overall EDP/ADP Market Involvement | | | |
| Objectives | | | |
| Activity Level in Minicomputer/ Microcomputer Product Line | | | |
| Financial Analysis | | | |
| Proximity/Accessibility for Service | | | |
| SUBTOTAL | | | |
| 2. SYSTEM RELATED | | | |
| a. Reliability and Maintainability: | | | |
| Central Processing Unit | | | |
| Main Memory (Core/RAM) | | | |
| Disk Drive | | | |
| Floppy Disk Drive | | | |
| Diskette Drive | | | |
| Magnetic Tape | | | |
| Printer | | | |
| Punch Card Reader | | | |
| Punch Paper/Mylar Tape Drive | | | |
| b. Cost Factors: | | | |
| Lease/Purchase Price | | | |
| Maintenance Cost | | | |
| c. Ancillary Features: | | | |
| Compatibility | | | |
| Growth/Upward Compatibility | | | |
| Main Memory Volatility | | | |
| Main Memory Expansion Limits | | | |
| Channel Capabilities and Expansion Limits | | | |
| Ease of Application | | | |
| Word Length | | | |
| Word Size | | | |
| Price of Additional Main Memory | | | |
| SUBTOTAL | | | |
| TOTAL | | | |

EXHIBIT 2 (CONT'D)

WEIGHTED EVALUATION SCHEDULE

| FACTOR | WEIGHT | RATING | SCORE |
|---|---|---|---|
| 1. COMPANY RELATED | | | |
| Overall EDP/ADP Experience | | | |
| State-of-the-Art Upkeep | | | |
| Overall EDP/ADP Market Involvement | | | |
| Objectives | | | |
| Activity Level in Minicomputer/ Microcomputer Product Line | | | |
| Financial Analysis | | | |
| Proximity/Accessibility for Service | | | |
| SUBTOTAL | | | |
| 2. SYSTEM RELATED | | | |
| a. Reliability and Maintainability of Operating System: | | | |
| Intertask Communication | | | |
| Shared Files Support | | | |
| Shared Programs (Reentrant) | | | |
| Multiprogramming | | | |
| Multitasking | | | |
| Batch | | | |
| Core Dump | | | |
| Power Failure/Recovery | | | |
| b. Language: | | | |
| FORTRAN Compiler/Interpreter | | | |
| PL/I Compiler/Interpreter | | | |
| APL Compiler/Interpreter | | | |
| Assembler | | | |
| Cross-Assembler | | | |
| c. System Utility: | | | |
| Conversational Editor/Text Editor | | | |
| System Command Language | | | |
| Stored Command Functions | | | |
| Task Builder | | | |
| File Transfer Programs | | | |
| SORTS | | | |
| On-line Debugging Tools | | | |

EXHIBIT 2 (CONT'D)

WEIGHTED EVALUATION SCHEDULE

| FACTOR | WEIGHT | RATING | SCORE |
|---|---|---|---|
| c. System Utility (cont'd): | | | |
| File Handling | | | |
| Communications | | | |
| Device Support | | | |
| Statistical Package | | | |
| Mathematical Programming Package | | | |
| Emulation Package | | | |
| Input/Output Logic or Circuiting | | | |
| Documentation | | | |
| Maintenance Cost | | | |
| Lease/Purchase Price | | | |
| d. Ancillary Features: | | | |
| Compatibility | | | |
| Growth/Upward Compatibility | | | |
| Ease of Application | | | |
| SUBTOTAL | | | |
| TOTAL | | | |
| GRAND TOTAL | | | |

EXHIBIT 3

PERFORMANCE MEASUREMENT SCHEDULE

| FACTOR | WEIGHT | RATING | SCORE |
|---|---|---|---|
| C. PERFORMANCE | | | |
| 1. GENERAL | | | |
| Field Support | | | |
| Hardware | | | |
| Software | | | |
| SUBTOTAL | | | |
| 2. CHARACTERISTICS | | | |
| a. Hardware: | | | |
| Ease of Use | | | |
| TSO Capability | | | |
| Print Quality | | | |
| RJE Capability | | | |
| Input/Output Speed | | | |
| Reliability | | | |
| Quality of Staff | | | |
| SUBTOTAL | | | |
| b. Software: | | | |
| Ease of Use | | | |
| Quality of Documentation | | | |
| Quality of Staff | | | |
| SUBTOTAL | | | |
| TOTAL | | | |
| GRAND TOTAL | | | |

TABLE 4

SUGGESTED WEIGHT SYSTEM

| WEIGHT | DESCRIPTOR |
|---|---|
| 50 | Critical |
| 40 | Major |
| 30 | Important |
| 20 | Desirable |
| 10 | Minor |

TABLE 5

SUGGESTED RATING SYSTEM

| RATING | DESCRIPTOR |
|---|---|
| 8-10 | Superior |
| 6-7 | Very Good |
| 5 | Good |
| 4 | Satisfactory--Meets all Minimum Requirements |
| 3 | Adequate |
| 2 | Poor |
| 1 | Reject |

## 4. FINDINGS AND CONCLUSIONS

### 4.1 Findings

Minicomputer/microcomputer systems are being used to perform the following kinds of tasks: monitoring and controlling specific processes, monitoring specified processes and displaying prescribed output, data retrieval, reduction and analysis, communication, inventory control, payroll, production control, scheduling, dispatching, S&E problem solving, management information systems, and word processing.

Savings can accrue from procuring and implementing a minicomputer/microcomputer system which satisfies the particular needs of a given user.

A clear distinction cannot be delineated among a minicomputer, microcomputer, and large-scale computer.

Minicomputer/microcomputer systems are manufactured which are compatible with present day computer systems, and permit upward compatibility and growth. (See the Glossary.)

### 4.2 Conclusions

It may be concluded that:

a. Before a purchaser or user procures a computer system, he (she) should evaluate his (her) specific computer requirements.

b. A minicomputer/microcomputer system that satisfies an individual user's requirements can be procured without difficulty. (There is no longer any need for a purchaser or user to buy more computing power than he (she) needs.)

## 5. RECOMMENDATION

It is recommended that the Directorate for Plans and Analysis, Systems and Cost Analysis Division, and other potential computer users evaluate their S&E and data management requirements for a large-scale computer system (its tie-in RJE and/or TSO terminals, and their associated telecommunications) versus a customized in-house minicomputer/ microcomputer system before acquiring additional computer support.

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# APPENDIX A

## MINICOMPUTER/MICROCOMPUTER MANUFACTURERS AND SOME OF THEIR SYSTEMS

TABLE 6

MINICOMPUTER/MICROCOMPUTER MANUFACTURERS
AND SOME OF THEIR SYSTEMS

| MANUFACTURER | CODE | COMPUTER |
|---|---|---|
| Altair Corp.<br>6200 Hiawatha Avenue<br>Chicago, IL 60646 | ALTAIR | 8800A/B |
| AMBAC Industries, Inc.<br>Roosevelt Field<br>Garden City, NY 11530 | AMBAC | MICRO D |
| Burroughs Corp.<br>Second Avenue at Burroughs<br>Detroit, MI 48976 | B | D-210 |
| Business Informations Technology, Inc.<br>5 Strathmore Road<br>Natick, MA 01760 | BIT | BIT-483 |
| Compiler Systems, Inc.<br>P. O. Box 366<br>Ridgefield, CT 06877 | CSI | CSI-16 |
| Computer Automation, Inc.<br>895 W. 16th St.<br>Newport Beach, CA 92660 | CAI | PDC-208; PDC-216 |
| Data General Corp.<br>Route 9<br>Southboro, MA 01772 | DG | NOVA; SUPER NOVA;<br>800; 1200 |
| Data Technology, Inc.<br>1050 E. Meadow Circle<br>Palo Alto, CA 94303 | DT | DT-1600 |
| Datamate Computer Systems<br>Box 310<br>Big Spring, TX 79720 | DCS | Datamate-16 |
| Digital Equipment Corp.<br>146 Main Street<br>Maynard, MA 01754 | DEC | PDP-8/I; PDP-8/L;<br>PDP-9/L; PDP-11/20;<br>PDP-15/10, TSS-8 |
| Electronic Associates, Inc.<br>187 Monmouth Park Hwy.<br>West Long Branch, NJ 07764 | EAI | EAI-640; MICRO-68 |

TABLE 6 (CONT'D)

| MANUFACTURER | CODE | COMPUTER |
|---|---|---|
| Exxon Enterprises Inc.<br>Zilog<br>540 New Haven Avenue<br>Milford, CT 06460 | ZILOG | Z-80 |
| Fairchild Camera & Instrument Corp.<br>464 Ellis Street<br>Mountain View, CA 94042 | F | F-8 |
| General Automation, Inc.<br>706 W. Katella<br>Orange, CA 92668 | GAI | SPC-12; SPC-16;<br>System 18/30 |
| General Instrument Corp.<br>1775 Broadway<br>New York, NY 10019 | GI | CP-1600 |
| GRI Computer Corp.<br>76 Howe Street<br>Newton, MA 02166 | GRI | 909 |
| Hewlett-Packard Co.<br>1501 Page Mill Street<br>Palo Alto, CA 94304 | HP | HP-9830; HP-2114A/B;<br>HP-2115A/B; HP-2116A/B |
| Honeywell, Inc.<br>Computer Control Division<br>Old Connecticut Path<br>Framingham, MA 01701 | HON | H-316; DDP-516 |
| Hughes Aircraft Co.<br>Centinela and Teale<br>Culver City, CA 90230 | H | HCH-201 |
| IMS Associates, Inc.<br>14860 Wicks Boulevard<br>San Leandro, CA 94577 | IMSAI | 8080 |
| Information Technology, Inc.<br>164 Wolfe Road<br>Sunnyvale, CA 94086 | ITI | 4900 |
| INTEL Corp.<br>3065 Bowers Avenue<br>Santa Clara, CA 95051 | INTEL | MCS-40; MCS-80 |

TABLE 6 (CONT'D)

| MANUFACTURER | CODE | COMPUTER |
|---|---|---|
| Interdata, Inc.<br>2 Crescent Place<br>Oceanport, NJ 07757 | INT | Model 3; Model 4 |
| International Business Machines<br>General Systems Division<br>875 Johnson Ferry Road, N.E.<br>Atlanta, GA 30342 | IBM | 5100; System 32;<br>Series 1 |
| IRA Systems, Inc.<br>332 Second Avenue<br>Waltham, MA 02154 | IRA | SPIRAS-65 |
| Lockheed Electronics, Inc.<br>Data Products Division<br>6201 E. Randolph Street<br>Los Angeles, CA 90022 | LEI | MAC 16 |
| Micro Systems, Inc.<br>644 East Young Street<br>Santa Ana, CA 92705 | MSI | 800; 810 |
| MOS Technology Inc.<br>Valley Forge Corporate Center<br>950 Rittenhouse Road<br>Morristown, PA 19401 | MOS | MCS-6500 |
| Motorola, Inc.<br>Box 5409<br>Phoenix, AZ 85010 | MOT | MC-6800; MDP-100 |
| Philco-Ford, Inc,<br>3939 Fabian Way<br>Palo Alto, CA 94303 | PFI | 1216-F |
| Radio Corporation of America<br>Solid State Division<br>New Holland Avenue<br>Lancaster, PA 17604 | RCA | CDP 1802 |
| Raytheon Computer<br>2700 South Fairview Street<br>Santa Ana, CA 92704 | RAY | 703; 706 |

TABLE 6 (CONT'D)

| MANUFACTURER | CODE | COMPUTER |
|---|---|---|
| Redcor Corp.<br>7800 Deering Avenue<br>P. O. Box 1031<br>Canoga Park, CA 91304 | RC | RC-70 |
| Rockwell International<br>3310 Miraloma Avenue<br>P. O. Box 3669<br>Anaheim, CA 92803 | RI | PPS-4; PPS-8 |
| Scientific Control Corporation<br>Box 96<br>Carrolton, TX 75006 | SCC | 4700 |
| System Engineering Laboratories, Inc.<br>Box 9148<br>Fort Lauderdale, FL 33310 | SEL | 810A/B |
| Tempo Computer, Inc.<br>340 West Collins Ave.<br>Orange, CA 92667 | TEM | TEMPO-1 |
| Sperry Rand Corp.<br>UNIVAC Division, Computer Systems<br>P. O. Box 500<br>Blue Bell, PA 19422 | UNIVAC | Add-1000 |
| Varian Data Machines, Inc.<br>2722 Michelson Drive<br>Irvine, CA 92664 | VDM | 520/i; 620/i |
| Wang Laboratories, Inc.<br>1 Industrial Ave.<br>Lowell, MA 08151 | WANG | WANG 2226; WANG 3300 |
| Westinghouse Electric Corp.<br>Computer and Instrumentation Div.<br>1200 West Colonial Drive<br>Orlando, FL 32804 | WES | Prodac-2000 |
| Xerox Data Systems<br>701 South Aviation Boulevard<br>El Segundo, CA 90245 | XDS | CE-16; CF-16;<br>SIGMA-3 |

# APPENDIX B

## ABBREVIATIONS, ACRONYMS AND SYMBOLS

## ABBREVIATIONS, ACRONYMS AND SYMBOLS

| | |
|---|---|
| ASCII | American Standard Code for Information Interchange |
| BCD | Binary Coded Decimal |
| BPI | Bits Per Inch |
| CPS | Characters Per Second; Cards Per Second |
| CPU | Central Processor Unit |
| CRT | Cathode Ray Tube |
| DASD | Direct Access Storage Devices |
| DMA | Direct Memory Access |
| DMC | Direct Multiplexor Channel |
| EBCDIC | Extended Binary Coded Decimal Information/Interchange Code |
| EPROM | Erasable Programmable Read Only Memory |
| EROM | Erasable Read Only Memory |
| ICP | International Computer Programs, Inc. |
| I/O | Input/Output |
| IPS | Inches Per Second |
| ISAM | Indexed Sequential Access System |
| ISP | Instruction Set Processor |
| K | 1, 024 words, 4-, 8-, 12-, 16-, 24-, 32-bit words |
| LPM | Lines Per Minute |
| LSI | Large-Scale Integration |
| μ | Micro, Millionth |
| MNOS | Metallic Nitride Oxide Semiconductor |
| MOS | Metallic Oxide Semiconductor |
| MPU | Microprocessor Unit |

| | |
|---|---|
| MSI | Medium-Scale Integration |
| NDRO | Nondestructive Read Out |
| OEM | Original Equipment Manufacturer |
| OS | Operating System |
| PROM | Programmable Read Only Memory |
| RA | Relative Address |
| ROM | Read Only Memory |
| UART | Universal Asynchronous Receiver-Transmitter |
| WCS | Work Core Storage |

# APPENDIX C

## GLOSSARY

## GLOSSARY

**Assembler** A computer program which translates symbolic assembly language input into machine language output; a computer program that converts the natural language (English, Swahili, etc.) equivalent of machine instructions into actual machine code on a one-for-one basis.

**Baud** A data transmission rate of one bit per second.

**Binary Coded Decimal (BCD)** A method of representing decimal digits in the form of four bit words.

**Bit** One binary digit.

**Byte** A cell in computer memory which can store eight binary bits of information; a unit of data which consists of eight binary digits.

**Compiler** A computer program which translates symbolic statements of a high level computer language input into machine language output; a language processor that evaluates algebraic source statements and produces object code (machine language) to solve the user's problem.

**Computer System** The sum total of the central processor unit (CPU): main memory, input/output from the CPU, mass storage, and software; a computer complete with the peripheral equipment and extensive software capabilities, operating system, compilers, interpreters, and application support, ready for application to problem solving.

**Cross-Assembler** Utilizing an assembler of another computer (preferably a large-scale computer) to produce operational machine code for a <u>host</u> computer.

**Distributed Computer Processing** Apportioning the computing power among various operating level user organizations through placement of select computer hardware and software systems in different geographic locations for direct user application; the marriage of telecommunication and minicomputer systems which emanate from different geographical locations but are linked to specific host computer systems; a network of hardware and software systems where operating level users (who originate and use data from various geographical locations) are permitted and encouraged to preprocess, access, and postprocess a substantial portion of the data on the network, while still leaving central control of the network to the host organization.

Erasable Read Only Memory (EROM) A special type of ROM which (a) can be programmed electrically, and (b) retain data even with the power disconnected, except it can be erased by exposure to short wave-length ultraviolet light.

Interpreter A computer program which translates symbolic statements of a high level computer language input into an immediate action; a computer program that converts the user's input (a source program) into a form which produces the desired output.

Interrupt Anything that causes a running program to be suspended, resulting in the activation of another program. (The user's program call causes an interrupt which invokes the operating system's executive module.)

Language Processor A computer program that accepts natural language input, analyzes it, and produces output as either the desired immediate action or in the machine language form.

Main Memory Core, solid state electronic, or bubble storage.

Mass Storage A medium for storing larger amounts of data than can fit into the main memory of a given processor at one time.

Microcomputer A microprocessor affixed with main memory, input/output logic or circuitry, and some programming facility which makes it capable of problem solving.

Microcomputer System An assemblage consisting of a microcomputer, peripheral equipment, and software, which are integrated to achieve the capability of problem solving.

Microprocessor A central processing unit (CPU) contained in a single semiconductor chip.

Microprocesser Unit (MPU) A CPU implemented with an integrated circuit microprocessor.

Minicomputer A small-scale computer (perhaps a large microcomputer), consisting of CPU, main memory, input/output circuitry, power supplies, and some programming facility.

Minicomputer System An assemblage consisting of a minicomputer, peripheral equipment, and software, which are integrated to achieve the capability of problem solving.

Object Code The machine code version of a computer program.

Operating System A computer program that controls and provides services to a user's application program, as well as controls system interrupt handling and other system activity. An operating system consists of three basic modules: executive, supervisor/command processor, and input/output device.

Original Equipment Manufacturer (OEM) A company that (a) produces or procures operating systems, systems applications and other software for target computer systems, (b) interacts directly with various computer hardware and peripheral equipment manufacturers for the marriage of computer hardware, peripheral equipment, and software of (and to procure, market, and maintain) target computer systems, and (c) markets and sells a complete package (computer hardware, peripheral equipment, software, and maintenance) to potential users.

Overlay A memory management method which may be used by a computer programmer to instruct the CPU to move data from a peripheral device to an area of memory that currently contains part of the program. The part of the program which is being replaced (overlaid) is stored in a peripheral. This memory management concept is under user control.

Page A computer memory concept wherein computer memory is divided into blocks of multiple bytes.

Parser A computer program mechanism which takes a set of syntax rules (a grammar) and an input string and decomposes the input string into tokens in accordance with the specified set of syntax rules.

Peripheral Any input/output device.

Programmable Read Only Memory (PROM) A ROM in which programming is performed by burning out fusable links at each cell. (This is accomplished by flowing a large current through the nichrome link.)

Random Access Memory (RAM) A set of memory cells which can have either a one or zero stored in it. (Individual cells may be accessed in any order.)

Read Only Memory (ROM) A memory device which has a fixed content in each location.

Real-Time Pertaining to the actual time during which a physical process transpires.

Service Bureau A company that markets and sells complete customized computer resources to potential users.

Simulator A computer program that is written for a specific minicomputer or large-scale computer system and used to interpret the assembly or machine language program that has been writen for a target computer system in order to produce the desired action. The idea is for the minicomputer or large-scale computer to emulate the target computer.

Source Program A nonmachine code version of a minicomputer program, e.g., Assembly, BASIC, FORTRAN, PL/I, etc.

Statement A computer programming language equivalent of a sentence in a natural language.

Subroutine A special purpose section of a computer program which is called upon to perform a specific function.

System A set of objects or components which is united by some form of interaction or interdependence.

Token A basic unit of the syntax of an expression.

Universal Asynchronous Receiver-Transmitter The transceiver converts serial input data to parallel output data at a rate determined by the receiver data clock. The transmitter accepts parallel input data and transmits it serially. It also inserts the desired number of start bits (at the transmitted word) and stop bits (at the end of the transmitted word). (A parity bit may be inserted.) Data are then transmitted out a baud rate determined by the transmitter data clock.

Upward Compatibility of Computer Hardware The capability and facility for the same series or later generation computer hardware system of a given manufacturer to fully exercise the software of the other. (If a computer software system works on a given manufacturer's product line, and also works on the same series, a larger, or later generation piece of computer hardware (from that manufacturer) in the same or a different product line, it is said to be upward compatible.)

Variable A symbolically named data location.

Virtual Memory A memory management method where main memory (which may be small) is made to look larger to the computer programmer. Without user control, ancillary memory, such as disk, magnetic tape, etc. is made to look like main memory to the computer programmer.

Word A set of characters that occupies one storage location and is treated by the computer circuits and transported as one unit; one unit of data.